Air Quality in Ontario 1989

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AIR QUALITY IN ONTARIO
1989

A review of the Ministry of the Environment
air quality monitoring program for 1989

TABLE OF CONTENTS

FIGURES

EXECUTIVE SUMMARY

In 1989, the routine air monitoring program in Ontario included the measurement of nine gases at up to 75 locations, the measurement of particulates at 152 locations and the measurement of meteorological parameters at 32 sites across Ontario.

For gases, undesirable air quality occurred on many occasions. The provincial air quality criterion (AQC) most frequently exceeded was that for ozone (O_3) and was largely associated with medium- and long-range transport of pollution from the United States. All 47 stations which monitor ozone, recorded exceedances of the criterion at least once during the year. The 24-hour criterion for suspended particles[1] (SP) was the second most frequently exceeded AQC. Out of 43 SP stations, 31 measured exceedances of the criterion at least once during 1989. Exceedances for sulphur dioxide (SO_2) and total reduced sulphur (TRS) occurred at some stations as well. There were two exceedances of the 1-hour nitrogen dioxide (NO_2), criterion during 1989. The ten-year trends indicate improvement for sulphur dioxide, carbon monoxide (CO) and total reduced sulphur, but little change in suspended particles, hydrocarbons (HC) and oxides of nitrogen (NO), (NO_2), and (NO_x). Although the number of exceedances of the 1-hour criterion for ozone was fewer than in 1988, the mean annual ozone levels remained high in 1989.

For "daily" particulates undesirable levels were reached on several occasions. The 24-hour criterion for total suspended particulate (TSP) was frequently exceeded. Out of 152 stations, 110 measured at least one exceedance during the year. Over the year, the average level of total suspended particulate was undesirable at thirty-seven of these stations (24%) which exceeded the annual AQC. Six of the 84 stations for which lead was analysed, measured exceedances of the criterion, while three out of 57 stations measured exceedances for nickel and two out of 54 stations recorded exceedances for manganese. The ten-year trends show improvement in total suspended particulate and lead.

Iron has shown an increase in the past three years while sulphate and nitrate have remained relatively constant over the 10-year period.

The Air Quality Index (AQI) system completed its first full year of measurements. Results showed that although for standard pollutants "good" to "very good" air quality levels prevailed most frequently at all AQI sites across the province (97% of the time or better), undesirable levels of "moderate" pollution did occur about 3% of the time. There were no incidences of "very poor" air quality reported at any location. Elevated levels of ozone and suspended particles are by far the most frequent cause of high index readings at the majority of AQI sites in Ontario. SO_2 was largely responsible for elevated AQI in Sudbury and TRS was the pollutant primarily responsible for high indices in Cornwall and Fort Frances.

The Air Pollution Index (API), which is still the basis of the alert system for air pollution control in Ontario, had at least one exceedance of the advisory level of 32 at eleven sites across Ontario. The API reached a maximum value of 38 at two locations in Toronto. One occurred on October 26 in York (36030) and the other on December 27 at North York West (34025). The alert was called for the API > 31 a total of 13 times during 1989.

Meteorological conditions such as wind speed and direction, atmospheric stability, quasi-stationary high pressure systems, and high air temperatures are shown to play a major role in the occurrence of high air concentrations of various pollutants. In some cases episodes with high levels of ozone or suspended particles found at several monitoring locations can be related to meteorological conditions.

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1. Particles with a diameter less than 44 microns are considered to behave as a gas since they are small enough to stay suspended for long periods of time. In our usage, the instrumentation which measures suspended particles (SP) restricts the size to particles less than about 10 microns. This is also the size range of most concern from a human health perspective.

INTRODUCTION

In the early 1950's, monitoring for sulphur dioxide began in the Sudbury area. In 1968, the province took over the responsibility for air pollution monitoring and by 1969, 76 sampling sites were operating throughout Ontario. In 1989 gaseous measurements were made at over 100 locations and particulates at 152 sites. It should also be noted that the Acidic Precipitation in Ontario Study (APIOS)[2] monitors wet and dry deposition of acidic and trace metal species at non-urban sites throughout Ontario.

This report describes the 1989 Ontario air quality monitoring program including a summary of the measurements of gases and particulate matter as well as a summary of meteorological conditions during the year. It is intended for use in conjunction with an Appendix which appears in a separate volume.

The ambient air quality data collected from the Ontario Ministry of the Environment monitoring network has been subjected to stringent quality control and quality assurance programs. The purpose of these programs is to ensure that the air quality data collected by the Ministry have attained acceptable levels of accuracy, precision and completeness. Section A of this report gives a brief discussion of the quality assurance and quality control procedures as well as a description of the data base.

This report discusses the following: characteristics, effects, Ontario criteria (if any), sources, method of monitoring, locations (and frequency) of sampling, summary of sampling results, and ten-year trends for each pollutant.

Also, tables are presented which provide the location of stations and the sample distribution information which includes means, maxima, percentiles and the number of exceedances of the Ontario criteria.

The entire continuous (hourly) network is summarized in Appendix Table A-1 and Maps 1 and 2. This table gives station name, numerical identifier, and an indication of the "continuous" pollutants measured. Letter codes indicate whether data were telemetered or chart-read.

The "continuous" pollutants include SP (suspended particles) as well as the following gases:

SO_2	(sulphur dioxide)
CO	(carbon monoxide)
O_3	(ozone)
NO_2	(nitrogen dioxide)
NO	(nitric oxide)
NOx	(oxides of nitrogen)
THC	(total hydrocarbons)
RHC	(reactive hydrocarbons)
CH_4	(methane)
TRS	(total reduced sulphur)

Section B of this report describes each of the "continuous" pollutants in sequence. Section C deals with the new Air Quality Index system which has completed its first full year of operation as well as the ten year history of the Air Pollution Index.

The particulate (daily) network is summarized in Appendix Table A-3 and Maps 4 and 5. This table provides station name, numerical identifier, and the various "daily" pollutants measured. Also, numerals indicate the monitoring cycle frequency in days. Some additional codes are defined in the key at the top of the table. The main particulate pollutants measured are:

TSP	(total suspended particulate)
Cd	(cadmium)
Cr	(chromium)
Fe	(iron)
Mn	(manganese)
Ni	(nickel)
Pb	(lead)
V	(vanadium)
NO_3^-	(nitrate)
SO_4^{2-}	(sulphate)

Section D describes each of the "daily" or particulate pollutants under the headings of TSP, Lead, Trace Metals, Nitrate and Sulphate. These data are collected at a frequency of once every 1, 3, or 6 days.

The meteorological network is described in Appendix Table A-5 and Maps 6 and 7. The table provides station name, numerical identifier, the various meteorological parameters measured as well as the height above ground at which the measurements were taken.

Section E summarizes the general meteorological conditions for 1989 and presents a brief discussion of episodes with moderate or poor air quality due to ozone and suspended particles.

Queries relating to this report or requests for data (magnetic tape or hard copy) should be addressed to:

Quality Assurance,
Telemetry and Analysis Unit
Air Resources Branch
125 Resources Road
Rexdale, Ontario
M9W 5L1
Telephone (416) 235-5780
or (416) 235-5778.

2.Contact for APIOS is Dr. N. Reid, Supervisor, Special Studies/Research Management, Air Resources Branch, 4th Floor, 880 Bay Street, Toronto, Ontario, M5S 1Z8, Tel. (416) 326-1691.

GLOSSARY

COH - the co-efficient of haze measurement yields an estimate of the amount of particulate matter by measuring the amount of light scattering.

Criterion - a desirable maximum ambient air exposure (based on effects).

Detection limit - the minimum air concentration of a pollutant that can be determined by a clearly specified analytical method.

Geometric mean - calculated by taking the nth root of the product of all (n) values in a data set.
- provides a better indication than arithmetic mean of the central tendency for a small data set with extreme values.

Percentile value - the percentage of the data set that lies below the stated value
- for example, if the 70 percentile value is 0:10 ppm, then 70% of the data are below 0.10 ppm.

Primary pollutant - a pollutant which is directly emitted to the atmosphere.

Secondary pollutant - a pollutant which is formed from other pollutants present in the atmosphere.

"Continuous" pollutant - a pollutant for which a continuous record exists; effectively, pollutants which have hourly average data (maximum 8760 values per year).

"Daily" pollutant - a pollutant for which there exists only a 24 hour or daily value (maximum 365 values per year).

ABBREVIATIONS

AQC - air quality criterion.

COH - coefficient of haze.

ppb - parts (of pollutant) per billion (parts of air).

ppm - parts (of pollutant) per million (parts of air).

$\mu g/m^3$ - micrograms (of pollutant) per cubic metre (of air).

SECTION A MONITORING NETWORK OPERATIONS

1.0 Quality Assurance and Quality Control

The Air Resources Branch maintains a reference standards laboratory with gas standards that are referenced to the U.S. National Bureau of Standards as well as to the Pollution Measurement Division of Environment Canada. Quarterly performance audits on the monitoring equipment and the data acquisition system in the MOE network are carried out in order to achieve maximum data accuracy. A ± 10 percent deviation from the audit standard is the criterion for performance acceptability.

The ambient air quality monitoring network is subjected to continuous maintenance and quality control programs. The real-time continuous and particulate air quality data are constantly reviewed, assessed and validated by regional staff and staff of the Air Resources Branch. Remedial actions are taken immediately to rectify any problems that may affect the validity of the data.

In 1989, the Provincial continuous air monitoring instruments were subjected to 834 performance audits. Seventy-five percent of the audits were found to be within the acceptable performance criterion of ± 10%. For the remaining 25% which fell outside the 10% criterion, station log records and backup charts were consulted in order to correct data where possible. As a result, the MOE monitoring network for 1989 had 95.4% valid data.

The particulate air monitoring instruments were subjected to 144 performance audits in 1989. Eighty-five percent of the audited instruments were within the ± 10% acceptable criterion.

1.1 Data Base

The ambient air quality data used in this report were obtained from MOE's Air Quality Information System (AQUIS). Approximately 4 million air pollution measurements are added to AQUIS on an annual basis, the vast majority of which represent the more heavily populated urban areas of Ontario.

Two statistical tests, namely, the pattern test and the gap test are used as a final data screening procedure to identify data anomalies. The pattern test checks for unusual pollutant behaviour. A set of limits for each pollutant has been defined from historical data. Values that are outside these limits are flagged for further investigation. The gap test identifies possible data anomalies by examining the length of the distance between the two largest values, the second and the third largest values, and similarly for other gaps.

The AQUIS data are divided into two major groupings: daily 24-hour measurements and continuous 1-hour measurements. The daily measurements are obtained from instruments that provide one measurement per 24-hour period and are typically operated on a 1,3 or 6 day sampling schedule. Such instruments are used to measure total suspended particulate, lead, various trace metals, sulphate and nitrate. For daily data, a valid annual mean requires at least two thirds of the total number of possible samples, i.e., a station operating on a 6-day sampling schedule would require at least 41 out of a possible 61 samples.

The 1-hour data are obtained from ambient air monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. A valid annual mean requires at least 5840 hourly readings (i.e., 67% valid readings).

In order for a monitoring site to have been included in the 10-year trend analysis, the site had to have air quality data for at least 8 out of the 10 years 1980-1989.

SECTION B
POLLUTANTS MEASURED BY CONTINUOUS MONITORS (HOURLY DATA)

SO_2
SULPHUR DIOXIDE

2.1 Characteristics
Colourless gas. Strong, pungent odour over 0.5 ppm.

2.2 Effects
1 hour average

less than .16 ppm	-	no known effects
0.16 ppm	-	injurious to sensitive species of vegetation in combination with ozone.
0.26 ppm	-	injurious to sensitive vegetation.
0.34 ppm	-	odourous, increasing vegetation damage.
2.00 ppm	-	increasing sensitivity of asthmatics and bronchitics.

2.3 Ontario Criteria
0.25 ppm (1-hour)
0.10 ppm (24-hours)
0.02 ppm (1-year)

2.4 Sources
80 percent of the SO_2 emitted in Ontario originates from non-ferrous smelters and electric utilities.

A major fraction of the remaining 20 percent comes from other industrial sources including iron ore smelters, petroleum refineries, pulp and paper mills and area sources including vehicles and residential, commercial and industrial heating.

2.5 Method of Monitoring
Fluorescent excitation of SO_2 by pulsed ultra-violet radiation.

2.6 Locations of Monitoring
The Appendix provides a description of the provincial SO_2 network (Table A-1).

SO_2 monitoring was carried out at 75 locations in 1989.

2.7 Monitoring Results
The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-6). Also given are the number of exceedances of the sulphur dioxide criteria (see Section 2.3).

The lowest annual average levels measured in the province were at one of the two monitoring stations in Thunder Bay where the hourly SO_2 never exceeded .02 ppm.

The greatest number of exceedances of the one-hour and 24-hour criteria occurred at Copper Cliff (77218) in Northeastern Ontario near the Inco Smelter operations. The highest annual mean (.020 ppm) was measured at Thorold (27052) in West-Central Ontario near an abrasives manufacturer and at Copper Cliff. There were a total of 18 stations which exceeded the hourly criterion at least once and seven which exceeded the 24-hour criterion. There were no stations which exceeded the annual criterion during 1989. (See Table 1).

2.8 Ten-Year Trend
The trend in mean annual SO_2 at locations which possess a ten-year record is shown in Table A-7 and is summarized for the province in Figure 1.

Mean ambient SO_2 levels improved by about 38% over the ten-year period. This is primarily due to tighter industrial emission controls and reduced sulphur content in fuels.

SP
SUSPENDED PARTICLES

3.1 Characteristics
A relative measure of suspended particulate matter of size most likely to reach the lungs (diameter less than 5-10 microns).
Determined by the amount of soiling caused by air flow on a filter medium.

3.2 Effects
1 hour average
less than 2.0 COH units - no known effects
2.0 COH units - decrease in visibility
4.0 COH units - soiling evident
6.0 COH units - increasing sensitivity of asthmatics and bronchitics

3.3 Ontario Criteria
1.0 COH unit (24-hours)
0.5 COH unit (1-year)

3.4 Sources
Industrial processes which include combustion, incineration, construction, mining, metal smelting, processing and grinding. Also motor vehicle exhaust and road dust.

Natural sources include wind-blown soil, forest fires, ocean spray, volcanic activity.

3.5 Method of Monitoring
Continuous paper tape sampler with sampling inlet and flow rate regulated to favour small particles.

SP is determined by drawing a known volume of air through a portion of tape and then measuring the reduction in the light transmitted relative to a clean section of tape.

3.6 Locations of Monitoring
The Appendix provides a description of the provincial SP network (Table A-1).

Suspended particles were measured at 43 locations in 1989.

3.7 Monitoring Results
The distribution by percentile of the hourly data, the mean, the maximum one-hour and 24-hour values, and the number of exceedances of the SP criteria (see Section 3.3) are provided in the Appendix (Table A-8).

The lowest levels measured in the province were at Cornwall (56051) where the SP averaged 0.11 COH units.

The greatest number of exceedances (53) of the 24-hour criterion and the highest annual mean (0.72 COH units) occurred at the Mission site (381 Yonge Street) in Toronto. The highest measured value (4.9 COH units) was at the Evans Avenue site (35033) in Etobicoke and in the City of York (36030).

There were a total of 31 stations which exceeded the 24-hour criterion at least once and three which exceeded the one-year criterion (See Table 1).

3.8 Ten-Year Trend
The trend in mean annual SP at selected Ontario cities is shown in Table A-9 and is summarized for the province in Figure 1.

Fine particulate, as determined by SP, has remained relatively constant over the past ten years. (See Section 19 for a further discussion on SP).

TRS

TOTAL REDUCED SULPHUR

4.1 Characteristics
Primarily hydrogen sulphide (rotten egg odour). Also methyl mercaptans (rotten cabbage odour over 5 ppb).

4.2 Effects
1 hour average

less than 5 ppb	-	no known effects
5 ppb	-	odour threshold
27 ppb	-	extremely odourous
1,000 ppb	-	sensitive individuals may suffer nausea and headache due to severe odour

4.3 Ontario Criteria

Methyl Mercaptans	- 10 ppb (1-hour)
Hydrogen Sulphide	- 20 ppb (1-hour)
TRS (from Kraft Pulp Mills)	- 27 ppb (1-hour)

4.4 Sources
Industrial - steel industry, pulp and paper mills, refineries.
Natural - swamps, bogs, marshes.

4.5 Method of Monitoring
Reduced sulphur compounds are oxidized to SO_2 and the SO_2 concentration is measured using fluorescent excitation by ultra-violet radiation.

4.6 Locations of Monitoring
The Appendix provides a description of the provincial TRS compounds network (Table A-1).

TRS monitoring was carried out at 32 locations in 1989.

4.7 Monitoring Results
The distribution by percentile of the hourly data, the mean, and the one-hour and 24-hour maxima are provided in the Appendix (Table A-10).

The lowest average levels measured in the province were at Thunder Bay (63200). The highest annual mean (5.0 ppb) and the greatest value measured (359 ppb) were recorded at Cornwall (56068) near a kraft paper mill. The greatest number of exceedances of the 1-hour TRS criterion occurred at Thorold (27052) near an abrasives manufacturer. (See Table 1).

4.8 Ten-Year Trend
Table A-11 shows the trend in mean annual TRS for selected Ontario cities while Figure 1 shows the provincial trend, with a minimum in 1985 and no change over the past two years.

CO

CARBON MONOXIDE

5.1 Characteristics
Colourless, odourless, tasteless gas which is produced as a result of incomplete combustion of carbonaceous fuels. It is of concern as an air pollutant because it has a strong affinity for haemoglobin and thus reduces the ability of blood to transport oxygen.

5.2 Effects
1 hour average

less than 30 ppm	-	no known effects
30 ppm	-	increased cardiovascular symptoms for smokers with heart disease
50 ppm	-	increasing cardiovascular symptoms for non-smokers with heart disease. Some visual impairment.

5.3 Ontario Criteria
30 ppm (1-hour)
13 ppm (8-hours)

5.4 Sources
Primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion for building, heating and commercial/industrial operations.

5.5 Method of Monitoring
Non-dispersive infrared photometry based on the preferential absorption of infrared radiation by CO.

5.6 Locations of Monitoring
The Appendix provides a description of the provincial CO network (Table A-1).

CO was monitored at 28 stations in 1989.

5.7 Monitoring Results
The distribution by percentile of the hourly data, the mean, and the maximum one-hour and eight-hour values are given in the Appendix (Table A-12).

The lowest levels measured in the province were at Sarnia (14064) while the highest mean was at the Mission site (381 Yonge Street) in Toronto. The highest measured one-hour and eight-hour values were also at the Mission site. This monitor is located in the Yonge Street corridor exposing it to motor vehicle exhaust.

There were no exceedances of the Ontario one-hour (30 ppm) or eight-hour (13 ppm) criteria during 1989. (See Table 1).

5.8 Ten-Year Trend
There was a 27% decline in ambient CO levels from 1980 to 1983 and, for the past 6 years CO levels have remained constant. (See Figure 1 and Table A-13). This is due primarily to tighter controls on automotive emissions.

THC/ RHC
HYDROCARBONS

6.1 Characteristics
Primarily methane (colourless, odourless) which is present at about 1.5 ppm in the ambient atmosphere. Non-methane hydrocarbons (or reactive hydrocarbons) are usually present at much lower levels. This fraction reacts with nitrogen oxides in the presence of sunlight to form ozone.

6.2 Effects
No known direct effects on health or vegetation at ambient levels.

6.3 Ontario Criteria
None. However, criteria and standards exist for specific hydrocarbons and other organics.

6.4 Sources
Natural sources include trees and other vegetation and decay of animal and plant material.

Anthropogenic sources include motor vehicles, gasoline storage tanks, petroleum and chemical industries, landfill sites, paint manufacture, application and fermentation.

6.5 Method of Monitoring
Calibrated flame ionization detector.

6.6 Locations of Monitoring
The Appendix provides a description of the provincial THC/RHC network (Table A-1).

RHC was monitored at two stations while THC was monitored at 9 locations in 1989.

6.7 Monitoring Results
The distribution by percentile of the hourly data; the mean; and the maximum one-hour and 24-hour values are given in the Appendix (Tables A-14 and A-15).

The locations and values for the lowest, and highest means are given in Table 1. The highest one-hour maximum concentration of reactive hydrocarbon compounds was measured at the University Avenue monitor in Windsor (12008) while the highest 1-hour total hydrocarbon value for the year was measured at the Centennial Park site (35003) in Etobicoke.

6.8 Ten Year Trend
The trend in the annual average of THC at the 6 stations which have a ten-year record is shown in Table A-15 and is summarized for the province in Figure 2. THC levels have remained relatively constant over the ten-year period.

NO_2
NITROGEN DIOXIDE

7.1 Characteristics
Reddish-brown gas with a pungent and irritating odour over .10 ppm. Oxidation product of nitric oxide (NO) which is the primary NOx emission. Reacts with hydrocarbons in sunlight to form ozone; and with water to form nitric acid, a component of acid rain.

7.2 Effects
1 hour average

less than .10 ppm	-	no known effects
0.10 ppm	-	odour threshold
0.25 ppm	-	some increase in bronchial reactivity in asthmatics
0.52 ppm	-	increasing sensitivity of asthmatics and bronchitics

7.3 Ontario Criteria
0.20 ppm (1-hour)
0.10 ppm (24-hours)

7.4 Sources
Anthropogenic - high temperature combustion processes including automobiles, power plants, incinerators and several chemical processes. In Ontario, motorized transportation accounts for about 60% of total NOx emissions.

Natural - lightning, soil bacteria.

7.5 Method of Monitoring
Based on the principle of chemiluminescence involving a gas phase reaction of NO with ozone. For NO_2, the sample stream is passed through a catalytic converter where NO_2 is reduced to NO.

7.6 Locations of Monitoring
The Appendix provides a description of the provincial NO_2 network (Table A-1).

NO_2 monitoring was carried out at 37 locations in 1989.

7.7 Monitoring Results
The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-17). Also given are the number of exceedances of the nitrogen dioxide criteria (see Section 7.3).

The lowest levels measured in the province were at Dorset where the arithmetic annual mean was .002 ppm.

The highest annual mean (.037 ppm) and the highest 1-hour average (.22 ppm) were measured in Toronto at the Mission site (31049).

There were two exceedances of the 1-hour (.20 ppm) criterion during 1989. One occurred in Kitchener (26029) and the other at the Mission monitor in Toronto. There were no exceedances of the 24-hour criterion. (See also Table 1).

7.8 Ten-Year Trend
The ten-year trend in the annual average of NO_2 at selected Ontario cities as shown in Table A-18, and Figure 2 is relatively constant.

NO
NITRIC OXIDE

8.1 Characteristics
Colourless gas. Oxidizes to NO_2 in the presence of hydrocarbons and sunlight.

8.2 Effects
No known direct effects on health or vegetation at ambient levels.

8.3 Ontario Criteria
None

8.4 Sources
Same as for NO_2.

8.5 Method of Monitoring
Same as for NO_2.

8.6 Locations of Monitoring
Same as for NO_2.

8.7 Monitoring Results
Long Point (22901) on the north shore of Lake Erie had the lowest annual mean and Toronto (31049) the highest. (See Appendix Table A-19 for the data summaries.)

8.8 Ten Year Trend
Figure 2 and Table A-20 show little change in NO over the past ten years.

NO_x
TOTAL NITROGEN OXIDES

NO_x is assumed to be the sum of NO_2 and NO concentrations in the atmosphere (in parts per million). (See Appendix Table A-21 for the data summaries.)

O_3
OZONE

10.1 Characteristics
Colourless gas. Major component of photochemical oxidant compounds formed as the result of chemical reactions between nitrogen oxides and reactive hydrocarbons in the presence of sunlight.

10.2 Effects
1 hour average

less than 50 ppb	-	no known effects
80 ppb	-	injurious to many species of vegetation
120 ppb	-	decreasing performance by athletes exercising heavily
200 ppb	-	decrease in lung function in exercising subjects, eye irritation

10.3 Ontario Criteria
80 ppb (1-hour)

10.4 Sources

Ozone is produced by photochemical reactions and is not directly emitted into the atmosphere in significant amounts. Since it is formed downwind of nitrogen oxide and hydrocarbon sources and capable of travelling long distances through the atmosphere, ozone is a manifestation of the long range transport of air pollution and a component of smog. Its formation and transport are dependent on meteorological factors. Warm temperatures are critical and elevated concentrations generally occur from May to September between noon and early evening. While the naturally occurring ozone in the stratosphere is beneficial to life by shielding the earth from harmful ultra-violet radiation given off by the sun, high concentrations of ozone at ground level are a major health and environmental concern.

10.5 Method of Monitoring

Chemiluminescence emission spectroscopy and U.V. absorbtion photometry.

In the first method, an air sample reacts with ethylene to emit visible light (chemiluminescence) of intensity directly proportional to the ozone concentration. In the second method, ozone absorbtion of U.V. light changes the intensity of the U.V. light beam, which is attenuated in proportion to the concentration of the ozone.

10.6 Locations of Monitoring

The Appendix provides a description of the provincial O_3 network (Table A-1).

Ozone monitoring was carried out at 47 locations in 1989.

10.7 Monitoring Results

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour values are provided in the Appendix (Table A-22). Also given are the number of exceedances of the ozone criterion (see Section 10.3).

The lowest levels measured in the province were at the Science Centre (34002) in North York where the annual mean was 12.4 ppb.

The highest annual mean concentration (35.7 ppb) was measured at Long Point Provincial Park (22901) while the maximum 1-hour averaged concentration occurred at Junction Triangle (31120) in Toronto. All 47 ozone stations exceeded the 1-hour criterion at least once. The greatest number of exceedances (265) occurred at the CN Tower (31190) where the height of the monitor is 444 metres. Concentrations aloft are higher than those at ground level and during the night they are decoupled from the ground by the nocturnal inversion. (See Table 1).

10.8 Ten-Year Trend

Table A-23 provides the ten-year trend for average O_3 at the stations where a ten-year record exists. Figure 2 summarizes the data for the province. The provincial mean has remained relatively constant with the exception of 1988 and 1989 during which long range transport of pollutants in conjunction with unusual meteorological conditions produced a provincial mean of 24.0 ppb and 23.4 ppb respectively. (See Section 19 for a further discussion on ozone).

TABLE 1 - HIGHLIGHTS OF THE CONTINUOUS MONITORING NETWORK 1989

	SO_2	SP	TRS	CO	THC	NO_2	NO	O_3
LOWEST MEAN LOCATION CONCENTRATION	THUNDER BAY (63200) 0 ppm	CORNWALL (56051) 0.11 COH UNITS	THUNDER BAY (63200) 0.2 ppb	SARNIA (14064) 0.3 ppm	TORONTO (31120) 1.87 ppm	DORSET (49010) .002 ppm	LONG POINT (22901) .001 ppm	NORTH YORK (34002) 12.4 ppb
HIGHEST MEAN LOCATION CONCENTRATION	COPPER CLIFF (77218) THOROLD (27052) .020 ppm	TORONTO (31049) 0.72 COH UNITS	CORNWALL (56068) 5.0 ppb	TORONTO (31049) 2.4 ppm	ETOBICOKE (35003) 2.27 ppm	TORONTO (31049) .037 ppm	TORONTO (31049) .075 ppm	LONG POINT (22901) 35.7 ppb
MOST CRITERION EXCEEDANCES-1HR LOCATION NUMBER	COPPER CLIFF (77218) 143	N/A	THOROLD (27052) 462*	- 0	N/A	KITCHENER (26029) TORONTO (31049) 1	N/A	TORONTO (31190) 265
MOST CRITERION EXCEEDANCES - 24 HR LOCATION NUMBER	COPPER CLIFF (77218) 14	TORONTO (31049) 53	N/A	N/A	N/A	- 0	N/A	N/A
NO. OF STATIONS EXCEEDING 1 HR AQC NUMBER	18	N/A	20	0	N/A	2	N/A	47
NO. OF STATIONS EXCEEDING 24 HR AQC NUMBER	7	31	N/A	N/A	N/A	0	N/A	N/A
HIGHEST MEASURED VALUE - 1HR LOCATION CONCENTRATION	SUDBURY (77201) 1.34 ppm	ETOBICOKE (35033) YORK (36030) 4.9 COH UNITS	CORNWALL (56068) 359 ppb	TORONTO (31049) 18 ppm	ETOBICOKE (35003) 11.6 ppm	TORONTO (31049) .22 ppm	KITCHENER (26029) .91 ppm	TORONTO (31120) 161 ppb
TOTAL NUMBER OF STATIONS NUMBER	75	43	32	28	9	37	37	47

* Exceedances of pulp mill criterion of 27 ppb for 1-hour.

Figure 1

10-Year Trend in Continuous Pollutants SO_2,SP,CO and TRS

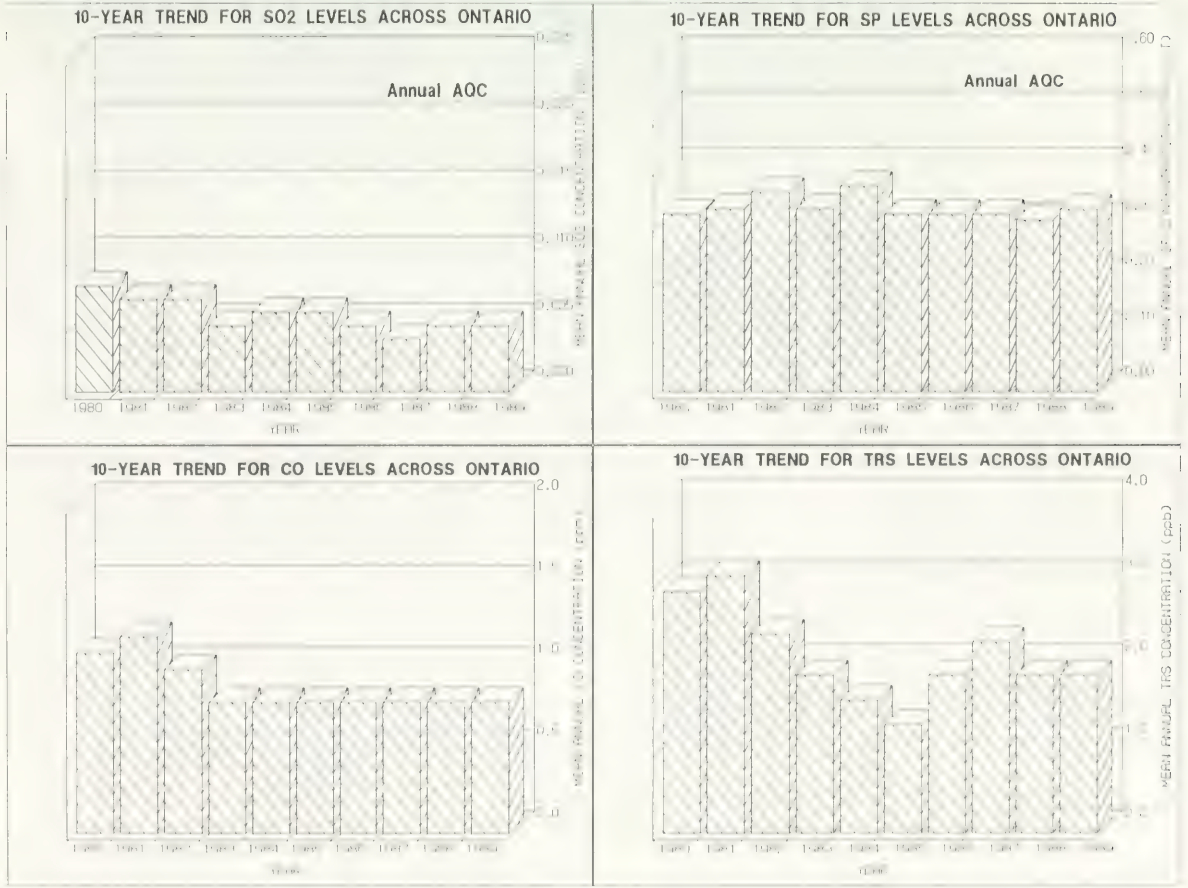
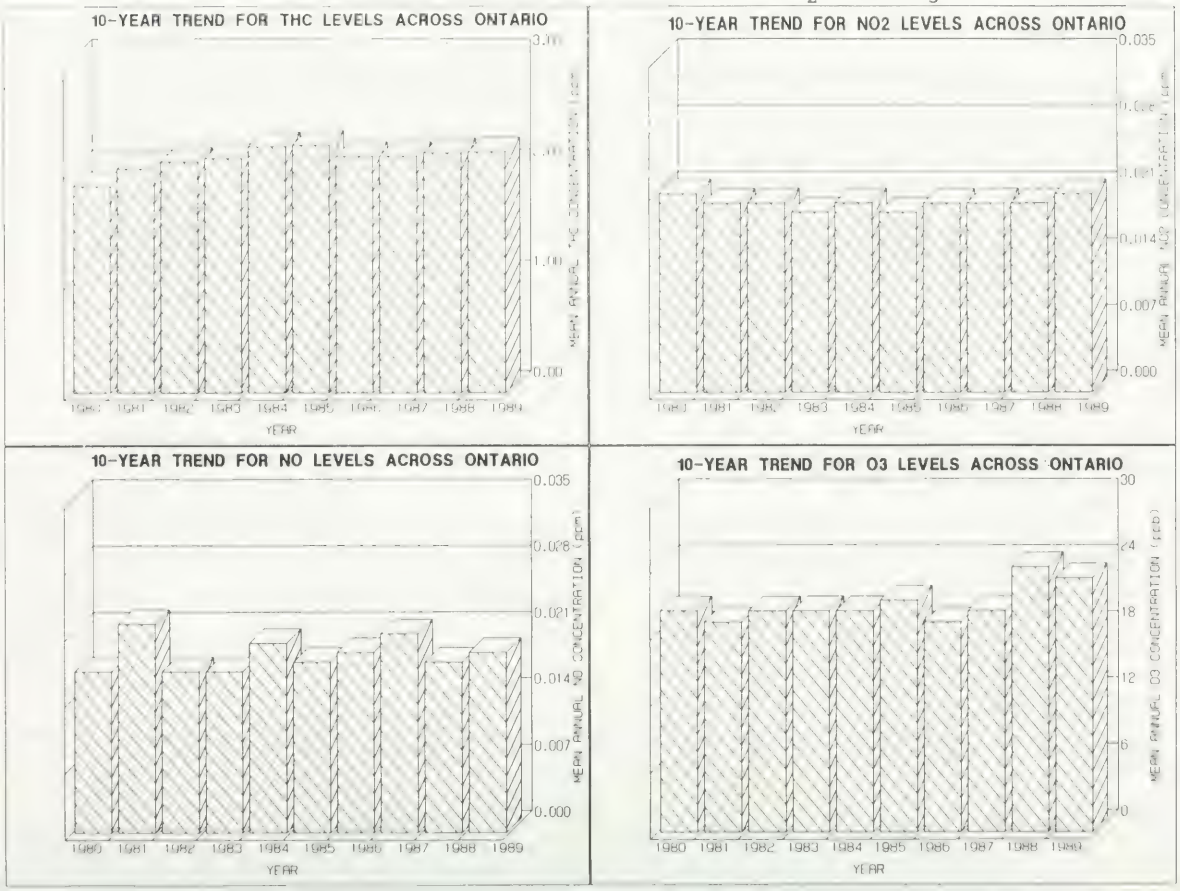


Figure 2

10-Year Trend in Continuous Pollutants THC, NO_2, NO and O_3



SECTION C
AIR QUALITY INDEX

11.1 Characteristics

The Air Quality Index (AQI) is a real-time information system that provides the public with an indication of air quality at 34 sites in 27 major cities across Ontario. The system has been in operation since June 1988. The AQI is derived from the sub-indices which are calculated for the pollutants that have evidence of adverse effects on the environment. These pollutants are sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur, carbon monoxide and suspended particles. In addition, the API (Section 12.0) is also included as one of the AQI sub-indices along with the eight-hour average of CO. The AQI is provided to the public eight times daily and it is increased to hourly releases when the index reaches 32, the level at which air quality is deemed moderate.

11.2 Effect

The AQI sub-index is calculated on a hourly basis for each pollutant. The sub-index increases as the air quality deteriorates. The index values, the corresponding categories and the health and environmental effects are given in Table 2. The highest sub-index at the given time becomes the AQI.

If the index value reaches 50 - 99, the air quality may have adverse effect on the most sensitive segment of the human or animal population, or may cause significant damage to vegetation, property, or aesthetic value. An AQI value of 100 or greater may cause adverse effect to the health of a large sector of the exposed population.

11.3 Operation of the System

There are 34 AQI monitoring sites in Ontario. The larger cities have more than one AQI station (See Map 3 in Appendix). The cities are selected according to population and previous air quality history. The data from the 34 AQI stations are accessed on a real-time basis by the computer center at the Air Resources Branch. The computed AQI's are released to the public, and the news media 8 times daily. In addition, AQI forecasts based on the meteorological conditions are issued four times daily. In the event that one of the AQI stations has an index greater than 31, the AQI information will be released hourly until it drops below 32.

11.4 Air Quality Index Levels (1989)

The frequency distribution of the hourly AQI according to descriptive category, and according to the pollutant responsible for AQI > 31 is shown for the thirty-four monitoring locations across Ontario in Table 3 . Figure 3 shows the percent frequency of unacceptable air quality (AQI > 31) according to the pollutant responsible while Figure 4 shows the number of hours of unacceptable air quality at AQI sites during 1989. In general, good to very good air quality levels prevailed at all sites throughout the province (97% of the time or better). Carbon monoxide was not responsible for unacceptable air quality levels at any AQI site during 1989. Nitrogen dioxide was in the unacceptable category for 1-hour at Kitchener. From Table 3 it is also evident that ozone and suspended particles were the most frequent cause of high index readings at the majority of the AQI sites. SO_2 was the most frequent cause of elevated AQI in Sudbury while total reduced sulphur compounds were the most frequent cause of high air quality indices in Cornwall and Fort Frances. There were no occurrences of very poor air quality reported at any location.

TABLE 2 - AIR QUALITY INDEX POLLUTANTS AND THEIR IMPACT

INDEX	CATEGORY	CARBON MONOXIDE CO	NITROGEN DIOXIDE NO_2	OZONE O_3	SULPHUR DIOXIDE SO_2	SUSPENDED PARTICLES SP TRS	SO_2 + SP (AS MEASURED BY THE API)	TOTAL REDUCED SULPHUR
100-over	Very poor	Increasing cardiovas-cular symptoms in non smokers with heart disease some visual impairment	Increasing sensitivity of patients with asthma and bronchitis	Light exercise produces respiratory effects in patients with chronic pulmonary disease	Increasing sensitivity in patients with asthma and bronchitis	Increasing sensitivity in patients with asthma and bronchitis	Significant respiratory effects in patients with asthma and bronchitis	Sensitive individuals may suffer nausea and headaches due to severe odour
50-99	Poor	Increased cardiovas-cular symptoms in smokers with heart disease	Odour and discolora-tion. Some increase in bronchial reactivity in asthmatics	Decreasing performance by athletes exercising heavily	Odourous increasing vegetation damage	Visibility decreased soiling evident	Increased symptoms in patients with chronic respiratory disease	Extremely odourous
32-49	Moderate	Blood chemistry but no detectable impairment	Odourous	Injurious to many vegetation species eg. white beans tomatoes etc.	Injurious to some species of vegetation	Some decrease in visibility	Injurious to vegetation due to sulphur dioxide	Odourous
16-31	Good	No effects	Slight odour	Injurious to some vegetation species in combination with SO_2 (4 hrs)	Injurious to some vegetation species in combination with ozone (4 hrs)	No effects	No effects	Slight odour
0-15	Very good	No effects	No effects	No effects	No effects	No effects	No effects	No effects

TABLE 3 - AIR QUALITY INDEX SUMMARY (1989)

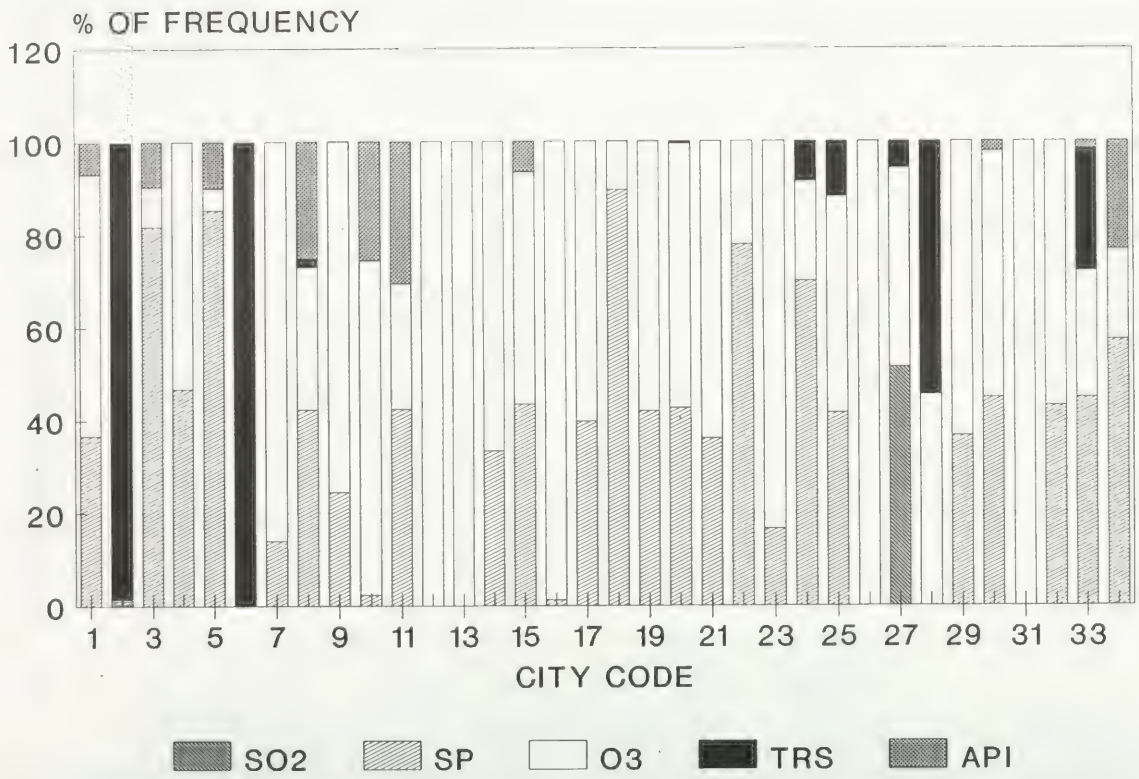
		NUMBER OF HOURS AQI IN RANGE					# OF HOURS POLLUTANT RESPONSIBLE FOR AQI >31						
Stn ID	CITY NAME	V-GOOD 0-15	GOOD 16-31	MOD 32-49	POOR 50-99	V-POOR 100+	SO_2	SP	O_3	TRS	CO	API	NO_2
44008	BURLINGTON	6792	1780	179	9	0	0	69	106	X	0	13	0
56051	CORNWALL	7561	917	200	66	0	1	2	1	262	0	0	0
32010	EAST YORK	7524	1132	102	2	0	0	85	9	X	0	10	0
35003	ETOBICOKE WEST	7511	792	76	1	0	0	36	41	X	0	0	0
35033	ETOBICOKE SOUTH	6342	2188	222	8	0	0	196	11	X	0	23	0
62030	FORT FRANCES *	921	41	117	43	0	X	X	X	160	X	X	X
28028	GUELPH	8094	612	43	0	0	0	6	37	X	X	0	X
29000	HAMILTON DOWNTOWN	6305	2247	206	2	0	0	88	64	4	0	52	0
29105	HAMILTON EAST	7859	852	49	0	0	0	12	37	X	X	0	X
29114	HAMILTON MOUNTAIN	7610	1107	43	0	0	0	1	31	0	X	11	0
29118	HAMILTON WEST	7256	1142	59	0	0	0	25	16	0	X	18	0
26029	KITCHENER	8381	362	17	0	0	0	X	16	X	0	X	1
52020	KINGSTON	6406	249	30	0	0	X	X	30	X	X	X	X
15001	LONDON	7669	998	91	2	0	0	31	62	X	0	0	0
46110	MISSISSAUGA	7575	971	204	10	0	0	93	107	X	0	14	0
27056	NIAGARA FALLS	7914	766	78	0	0	0	1	77	X	X	0	X
34020	N. YORK CENTRAL	7504	1188	65	3	0	0	27	41	X	0	0	0
34025	N. YORK WEST	6790	1770	48	0	0	0	43	5	X	0	0	0
75010	NORTH BAY	7719	908	62	0	0	0	26	36	X	0	0	0
44015	OAKVILLE	6908	1655	194	3	0	0	84	112	1	0	0	0
45025	OSHAWA	7507	1128	125	0	0	0	45	80	X	0	0	0
51001	OTTAWA	7829	876	36	0	0	0	28	8	X	0	0	0
14064	SARNIA	7529	1006	85	6	0	0	15	76	0	0	0	0
71068	SAULT STE. MARIE	7859	729	70	0	0	0	49	15	6	0	0	0
33003	SCARBOROUGH	7462	1180	112	6	0	0	49	55	X	0	14	0
27067	ST. CATHARINES	8282	468	10	0	0	0	0	10	X	0	0	0
77203	SUDBURY	7874	851	26	9	0	18	0	15	2	X	0	0
63200	THUNDER BAY	8634	115	11	0	0	0	0	5	6	0	0	0
31104	TORONTO DOWNTOWN	7908	811	39	2	0	0	15	26	X	0	0	0
31120	TORONTO WEST	7647	968	135	10	0	0	65	77	X	0	0	0
26045	WATERLOO	8163	580	12	0	0	0	0	12	X	X	0	X
12008	WINDSOR UNIVERSITY	7405	1069	99	1	0	0	43	57	X	0	0	0
12016	WINDSOR COLLEGE	7430	1146	174	9	0	0	82	50	48	0	3	0
36030	YORK	7273	1267	208	12	0	0	126	43	X	0	51	0

FOOTNOTES: * FORT FRANCES BECAME AN AQI SITE ON NOV. 15, 1989

X POLLUTANT NOT MEASURED AT SITE

Figure 3

PERCENT FREQUENCY OF UNACCEPTABLE AIR QUALITY ACCORDING TO POLLUTANT RESPONSIBLE AT AQI SITES ACROSS ONTARIO (1989)

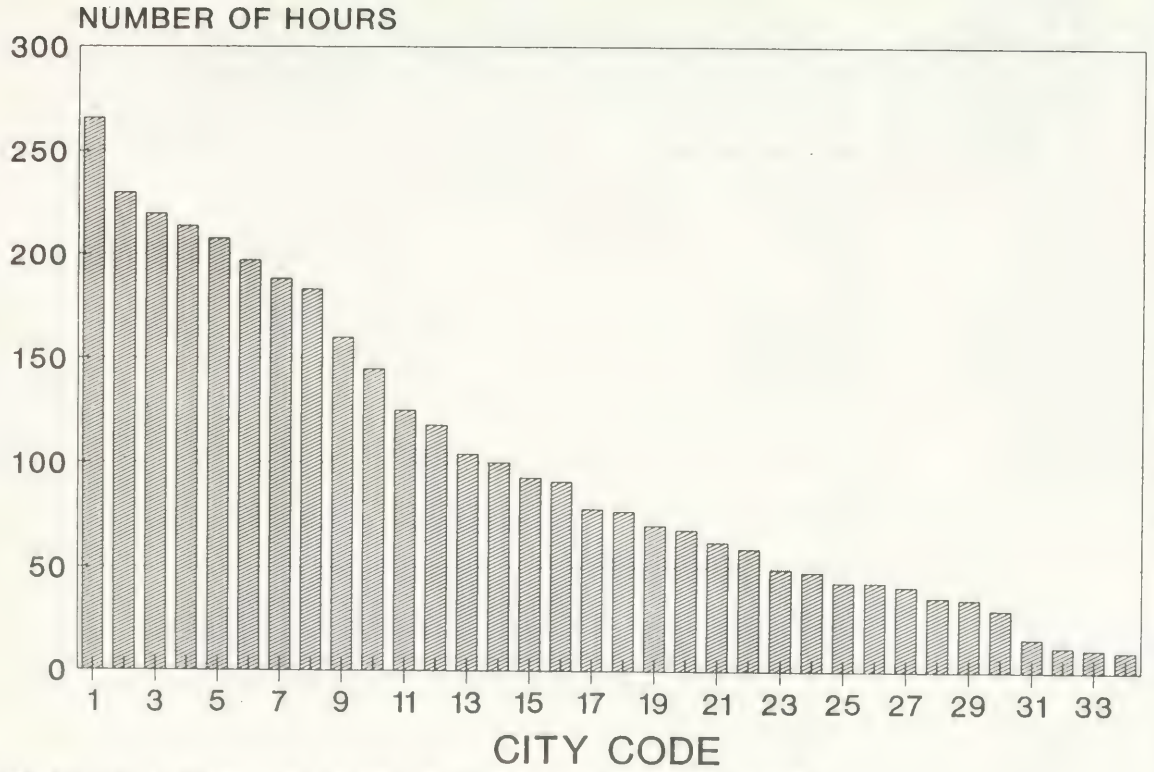


1 Burlington
2 Cornwall
3 East York
4 Etobicoke West
5 Etobicoke South
6 Fort Frances
7 Guelph
8 Hamilton Downtown
9 Hamilton East
10 Hamilton Mountain
11 Hamilton West
12 Kingston
13 Kitchener
14 London
15 Mississauga
16 Niagara Falls
17 North York Central
18 North York West
19 North Bay
20 Oakville
21 Oshawa
22 Ottawa
23 Sarnia
24 Sault Ste Marie
25 Scarborough
26 St. Catharines
27 Sudbury
28 Thunder Bay
29 Tor. Downtown
30 Tor. West
31 Waterloo
32 Windsor - U.
33 Windsor - College
34 York

Note: CO was not responsible for unacceptable Air Quality in 1989
NO2 was unacceptable for 1 hour at Kitchener in 1989
Fort Frances came on line Nov. 15, 1989

Figure 4

NUMBER OF HOURS OF UNACCEPTABLE AIR QUALITY AT AQI SITES IN ONTARIO (1989)



1 Cornwall
2 Etobicoke South
3 York
4 Mississauga
5 Hamilton Downtown
6 Oakville
7 Burlington
8 Windsor - College
9 Fort Frances
10 Tor. West
11 Oshawa
12 Scarborough
13 East York
14 Windsor - University
15 London
16 Sarnia
17 Niagara Falls
18 Etobicoke West
19 Sault Ste Marie
20 North York Central
21 North Bay
22 Hamilton West
23 Hamilton East
24 North York West
25 Hamilton Mountain
26 Guelph
27 Tor. Downtown
28 Ottawa
29 Sudbury
30 Kingston
31 Kitchener
32 Waterloo
33 Thunder Bay
34 St. Catharines

Note : Fort Frances came on line November 15, 1989

AIR POLLUTION INDEX (API)

12.1 Characteristics

The API continues to be the basis of an alert and control system to warn of deteriorating air quality and is derived from 24-hour running averages of sulphur dioxide and suspended particles. Research studies have linked respiratory illness to elevated concentrations of sulphur dioxide and particulates.

12.2 Legislation

The Ontario Environmental Protection Act (1971) authorizes the Minister of the Environment to order any point source not essential to public health or safety to curtail or cease its operations when air pollution levels which may be injurious to health occur.

12.3 Operation of the System

The API is computed each hour based on the past 24 hourly values for SO_2 and SP. If the index reaches a value of 32 (as for example when SO_2 = 0.1 ppm and SP = 1.0) and if the Duty Meteorologist predicts a continuation of adverse atmospheric conditions for at least six hours, an Air Pollution Advisory is issued. Owners of significant sources of pollution are advised to prepare for possible curtailment of operations.

If the index reaches 50, and if at least six hours of adverse atmospheric conditions are forecast, owners of major sources may be ordered to curtail operations. This is the First Alert Level.

A Second Alert is issued at an API of 75, and further curtailment may be ordered.

The Air Pollution Episode Threshold Level occurs at an API of 100. If atmospheric conditions are not expected to improve for at least six hours, owners of all sources not essential to public health or safety may be ordered to cease operations.

12.4 Air Pollution Index Levels (1980 - 1989)

A history of the Air Pollution Index levels over the last 10 years of its operation is provided in Table 4.

TABLE 4
TEN YEAR HISTORY OF THE AIR POLLUTION INDEX (1980-1989)

YEAR	CITY	NUMBER OCCASIONS >31	NUMBER OCCASIONS >49	MAXIMUM INDEX	DATE OF MAXIMUM
1980	TORONTO	0	0	31	Dec. 8
	HAMILTON	5	0	40	Oct. 16
	SUDBURY	0	0	23	Oct. 16
	WINDSOR (12008)	0	0	25	Feb. 8, 9
	WINDSOR (12016)	0	0	25	Dec. 29
	NIAGARA FALLS	0	0	18	May 24
	CONISTON	0	0	30	Feb. 10, Mar.9
	NEW SUDBURY	0	0	24	Jul. 3, Oct.16
	SARNIA	1	0	39	Mar. 20
	ST. CATHARINES	0	0	28	Feb. 20
1981	TORONTO	3	0	43	Nov. 14
	HAMILTON	8	0	38	Nov. 15
	SUDBURY	0	0	21	Jan. 31
	WINDSOR (12008)	1	0	42	Nov. 17
	WINDSOR (12016)	0	0	31	Nov. 17
	NIAGARA FALLS	0	0	25	Jan. 14
	CONISTON	0	0	20	Nov. 25
	NEW SUDBURY	0	0	22	Jan. 28-29
	SARNIA	1	0	34	Feb. 16
	ST. CATHARINES	0	0	27	Jan. 14-15

Table 4 (cont'd)

YEAR	CITY	NUMBER OCCASIONS >31	>49	MAXIMUM INDEX	DATE OF MAXIMUM
1982	TORONTO	3	2	54	Oct. 27
	HAMILTON	12	0	39	Dec. 2
	SUDBURY	0	0	15	Feb. 3
	WINDSOR (12008)	0	0	31	Oct. 26-27
	WINDSOR (12016)	1	0	35	Oct. 27
	NIAGARA FALLS	0	0	19	Jan. 19
	CONISTON	1	0	39	Feb. 5
	NEW SUDBURY	0	0	29	Feb. 5
	SARNIA	0	0	27	Mar. 11, Nov.7-8
	ST. CATHARINES	0	0	31	Nov. 18
1983	TORONTO	3	0	39	Jan. 29
	HAMILTON	1	0	37	Mar. 2
	SUDBURY	1	0	39	Jan. 22
	WINDSOR (12008)	0	0	26	Sep. 27
	WINDSOR (12016)	1	0	33	Mar. 1-2
	NIAGARA FALLS	0	0	17	Jan. 30
	CONISTON	0	0	19	Jan. 15
	NEW SUDBURY	1	1	63	Jan. 22
	SARNIA	0	0	28	Jan. 29
	ST. CATHARINES	0	0	23	Jan. 30
1984	TORONTO	2	1	50	Jan. 16
	HAMILTON	8	0	44	Nov. 27
	SUDBURY	0	0	23	Feb. 1
	WINDSOR (12008)	0	0	31	Oct. 2, Nov. 14
	WINDSOR (12016)	1	0	40	Feb. 15
	NIAGARA FALLS	0	0	20	Dec. 10-11
	CONISTON	0	0	29	Nov. 22
	NEW SUDBURY	0	0	23	Nov. 22
	SARNIA	0	0	27	Jan. 23
	ST. CATHARINES	0	0	24	Feb. 10-11
1985	TORONTO	0	0	25	Apr. 23
	HAMILTON	2	0	36	Apr. 23-24
	SUDBURY	0	0	31	Aug. 4
	WINDSOR (12008)	0	0	25	Dec. 20
	WINDSOR (12016)	0	0	30	Dec. 20
	NIAGARA FALLS	0	0	19	Apr. 24
	CONISTON	0	0	19	Mar. 26
	NEW SUDBURY	0	0	31	Jan. 7
	SARNIA	0	0	20	Mar. 27-28
	ST. CATHARINES	0	0	18	Dec. 6
1986	TORONTO	0	0	22	Jan. 17
	HAMILTON	5	0	37	May 15
	SUDBURY	0	0	23	Oct. 26
	WINDSOR (12008)	0	0	31	Jan. 16, Oct. 22, Dec. 16
	WINDSOR (12016)	0	0	29	Mar. 14
	NIAGARA FALLS	0	0	17	Jan. 17
	CONISTON	0	0	18	Mar. 20-21
	NEW SUDBURY	0	0	20	Apr. 23
	SARNIA	0	0	29	Dec. 17
	ST. CATHARINES	0	0	18	Jan. 17

Table 4 (cont'd)

YEAR	CITY	NUMBER OCCASIONS >31	>49	MAXIMUM INDEX	DATE OF MAXIMUM
1987	TORONTO	0	0	31	Oct. 16
	HAMILTON	2	0	38	Oct. 17
	SUDBURY	0	0	26	Mar. 14
	WINDSOR (12008)	0	0	24	Apr. 10
	WINDSOR (12016)	0	0	20	Jun. 25, Oct. 24
	NIAGARA FALLS	0	0	16	Oct. 16-17
	CONISTON	0	0	23	Mar. 9, Mar. 11
	NEW SUDBURY	0	0	22	Mar. 11, Mar.14, Aug. 27
	SARNIA	0	0	24	Jan. 28
	ST. CATHARINES	0	0	24	Oct. 16-17
1988	TORONTO DOWNTOWN	0	0	22	Jul. 7
	HAMILTON DOWNTOWN	1	0	43	Nov. 25-26
	SUDBURY	0	0	25	Jun. 17-18
	WINDSOR (12008)	0	0	28	Nov. 23;Dec.7
	WINDSOR (12016)	0	0	24	Jan. 8-9
	NIAGARA FALLS	0	0	20	Nov. 26
	&CONISTON	0	0	21	Apr. 19
	&NEW SUDBURY	0	0	21	Jun. 15
	SARNIA	0	0	26	Jan. 30
	ST. CATHARINES	0	0	14	Jul. 31
	*TORONTO WEST	0	0	13	Dec. 13
	*EAST YORK	0	0	22	Nov. 4
	*SCARBOROUGH	0	0	29	Sep. 30
	*NORTH YORK CENTRAL	0	0	23	Nov. 26
	*NORTH YORK WEST	0	0	27	Nov. 26
	*ETOBICOKE WEST	1	0	33	Nov. 26
	*ETOBICOKE SOUTH	0	0	29	Nov. 26
	*YORK	0	0	29	Nov. 26
	*BURLINGTON	0	0	27	Sep. 8-9
	*OAKVILLE	0	0	24	Sep. 2
	*OSHAWA	0	0	23	Jun. 15;Jul.7
	*MISSISSAUGA	0	0	18	Jul. 19
	*LONDON	0	0	22	Nov. 26
	*KITCHENER	0	0	26	Aug. 2
	*WATERLOO	0	0	17	Nov. 25-26
	*GUELPH	0	0	18	Nov. 26
	*HAMILTON EAST	0	0	20	Nov. 26
	*HAMILTON MOUNTAIN	0	0	23	Nov. 26
	*HAMILTON WEST	0	0	26	Nov. 25-26
	*SAULT STE MARIE	0	0	24	Jun. 20
	*NORTH BAY	0	0	16	Nov. 26
	*OTTAWA	0	0	18	Aug. 5;Dec.19-20
	*CORNWALL	0	0	20	Jun. 7
	*THUNDER BAY	0	0	5	Nov. 24-25

* started June, 1988
& closed May, 1988

Table 4 (cont'd)

YEAR	CITY	NUMBER OCCASIONS >31	>49	MAXIMUM INDEX	DATE OF MAXIMUM
1989	TORONTO DOWNTOWN	0	0	28	Oct. 26
	HAMILTON DOWNTOWN	3	0	37	Oct. 30-31
	SUDBURY	0	0	24	Sep. 14
	WINDSOR (12008)	0	0	27	Oct. 27
	WINDSOR (12016)	1	0	32	Oct. 27
	NIAGARA FALLS	0	0	21	Oct. 29
	SARNIA	0	0	26	Oct. 27-28
	ST. CATHARINES	0	0	18	Mar. 10
	TORONTO WEST	1	0	33	Oct. 26
	EAST YORK	1	0	34	Oct. 26
	SCARBOROUGH	1	0	34	Oct. 26
	NORTH YORK CENTRAL	0	0	26	Oct. 26
	NORTH YORK WEST	1	0	38	Dec. 27
	ETOBICOKE WEST	0	0	29	Oct. 26
	ETOBICOKE SOUTH	2	0	33	Oct. 26
	YORK	2	0	38	Oct. 26
	BURLINGTON	1	0	34	Aug. 12
	OAKVILLE	0	0	27	Oct. 26
	OSHAWA	0	0	29	Oct. 27-28
	MISSISSAUGA	1	0	35	Oct. 26
	LONDON	1	0	32	Oct. 27
	WATERLOO	0	0	19	Aug. 12
	GUELPH	0	0	19	Oct. 27-28
	HAMILTON EAST	0	0	24	Oct. 31
	HAMILTON MOUNTAIN	0	0	22	Oct. 28-29
	HAMILTON WEST	0	0	29	Oct. 31
	SAULT STE MARIE	0	0	24	Sep. 14
	NORTH BAY	0	0	19	Jan. 24,Feb.17
	OTTAWA	0	0	27	Jan. 24
	CORNWALL	0	0	19	Feb. 18

SECTION D
POLLUTANTS MEASURED BY HIGH VOLUME SAMPLER MONITORING (DAILY DATA)

TSP
TOTAL SUSPENDED PARTICULATE

13.1 Characteristics
Total suspended particulate is a generic term for airborne particles including smoke, fume, dust, fly ash and pollen. Composition varies with place and season but normally includes soil particulates, organic matter, sulphur and nitrogen compounds and metals such as lead. Size range is approximately .1 to 100 microns (diameter).

13.2 Effects
The greatest impact on health is from particles less than 10 microns in diameter which can penetrate deep into the lungs and contribute to respiratory disease. More serious health effects may be associated with suspended particulate matter which contains a toxic particulate component or which has absorbed a gaseous pollutant on the surface of the particles. Corrosion, soiling, damage to vegetation and visibility reduction are additional effects.

13.3 Ontario Criteria
120 $\mu g/m^3$ (24-hours)
60 $\mu g/m^3$ (1-year - geometric mean)

13.4 Sources
Natural sources include wind-blown soil, forest fires and plant pollen. Anthropogenic sources include combustion, incineration, construction, mining, metals smelting and processing, grinding processes, agricultural activity and transportation.

13.5 Method of Monitoring
By High Volume Sampler. Air is drawn through a filter at the rate of approximately 1.4 m^3/min. The (daily) mass concentration of total suspended particulate matter is computed from the mass of collected particles and the volume of air sampled.

13.6 Location and Frequency of Monitoring
The monitoring locations and the frequency of sampling at each location are indicated in the Appendix (Table A-3).

TSP was measured at 152 locations in 1989.

13.7 Monitoring Results
The distribution by percentile, the maximum, the arithmetic mean and the geometric mean are given in the Appendix (Table A-24). Also given are the number of exceedances of the 24-hour and one-year criteria. The lowest levels measured in the province were at Dorset (49010) where the annual mean was 19 $\mu g/m^3$.

The highest annual mean (107 $\mu g/m^3$) was recorded at Hamilton (29011) while the maximum daily value (870 $\mu g/m^3$) was measured in Toronto (31082). The greatest percentage of exceedances (42) of the 24-hour criterion occurred at both Hamilton (29011) and Sault Ste Marie (71042).

There were a total of 110 stations which exceeded the 24-hour criterion and 37 which exceeded the one-year criterion. (See Table 5).

13.8 Ten-Year Trend
The trend in mean annual TSP at locations which possess a ten-year record is shown in Table A-25 and is summarized for the province in Figure 5. Particulate levels have improved since 1980 by about 20%, however, there has been a 5% increase over the past year.

Pb
LEAD IN SUSPENDED PARTICULATE

14.1 Characteristics
A silver bluish, white, soft metal. Molecular weight 207.20.

14.2 Effects
Can degrade renal function, impair haemoglobin synthesis, and alter the nervous system.

14.3 Ontario Criteria
5.0 $\mu g/m^3$ (24-hours)
2.0 $\mu g/m^3$ (30-day - geometric mean)

14.4 Sources
Combustion of gasoline containing lead additives, secondary smelting of lead, battery manufacture, metal fabrication, some paint and glass manufacture, production of iron, steel, copper and nickel.

Lead emissions fell significantly after 1975 with the introduction of lead-free gasoline.

14.5 Method of Monitoring
Lead concentration on high volume filters determined by either X-Ray fluorescence or atomic absorption.

14.6 Location and Frequency of Monitoring

The monitoring locations and sampling frequency for each location are indicated in the Appendix (Table A-3).

Lead was measured at 84 locations in 1989.

14.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean and the geometric mean are given in the Appendix (Table A-26). Also given are the number of exceedances of the 24-hour criterion.

The greatest percentage of exceedances of the 24-hour criterion occurred at Mississauga (2414 Dixie Road) in the vicinity of a lead processing plant. The highest annual mean and the highest measured value occurred there also.

There were a total of six stations which exceeded the daily criterion at least once (see Table 5).

14.8 Ten-Year Trend

Lead levels in air have improved very significantly over the past ten years (see Figure 5).

The trend at selected Ontario cities is shown in Table A-27; the decline (90%) is largely due to the decreased use of leaded gasoline.

TRACE METALS

CADMIUM, CHROMIUM, IRON, MANGANESE NICKEL, VANADIUM

15.1 Characteristics

Name	Symbol	Properties	Molecular Weight
Cadmium	Cd	silver white, hexagonal	112.41
Chromium	Cr	steel grey, cubic	52.00
Iron	Fe	silver, cubic	58.85
Manganese	Mn	grey-pink, cubic	54.94
Nickel	Ni	silver, cubic	58.60
Vanadium	V	light grey, cubic	50.94

15.2 Effects

Depth of penetration into the respiratory system (and consequently risk to health) increases as particle size decreases. Of the heavy metals, cadmium, chromium, vanadium and manganese probably pose the greatest risk to human health. Soiling and damage to vegetation are additional effects.

15.3 Ontario Criteria

	24 Hour Criterion	
Cadmium	2	$\mu g/m^3$
Chromium	1.5	$\mu g/m^3$
Manganese	2.5	$\mu g/m^3$
Nickel	2	$\mu g/m^3$
Vanadium	2	$\mu g/m^3$

15.4 Sources

See Section 2.4.

15.5 Method of Monitoring

Collection is by High Volume Sampler (see Section 13.5). Following determination of TSP, a portion is cut from the exposed filter and ashed to destroy carbonaceous matter. The ashed sample is then digested in acid, and analyzed by atomic absorption spectrophotometry. The mass concentration of each metal in ambient air is calculated from the mass of each metal in TSP and the volume of air sampled, and expressed in $\mu g/m^3$.

15.6 Location and Frequency of Sampling

The monitoring locations and the sampling frequency for each location are indicated in the Appendix (Table A-3).

Metals were measured at 53 to 58 stations depending on the element.

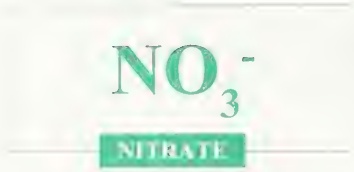
15.7 Monitoring Results

The distribution by percentile of the daily data, the maximum, the arithmetic mean, the geometric mean, and the number of exceedances of the daily criterion are provided in the Appendix for iron, manganese, nickel, chromium, cadmium and vanadium. Table A-35 shows the maximum monitored levels for all the trace metals listed above. No table is provided for copper because studies have shown that copper measurements may be affected by contamination of the sample by the hi-vol motor. The contamination is highest when a new motor is installed and decreases with motor age. No attempt has been made to correct the data; however, it is available upon request.

Table 5 provides the highlights of particulate monitoring for 1989. It shows that nine exceedances of the air quality criteria for metals (exclusive of lead) occurred in 1989. Nickel was responsible for seven of these exceedances and manganese was the metal responsible for the other two. For nickel, four exceedances occurred at Copper Cliff (77070), one at Sudbury (77016) and two at Port Colborne (27047). For manganese, one exceedance was recorded at Sault Ste Marie (71042) and the other exceedance was measured at Hamilton (29025). Such exceedances may be harmful to vegetation.

15.8 Ten-Year Trend

The trend in mean annual iron is shown in Table A-29 and is summarized for Ontario in Figure 3. Iron shows a decline from 1980 to 1986 followed by a 28% increase over the past three years.



16.1 Characteristics

Nitrogen oxide compounds, formed from atmospheric nitrogen and oxygen through high temperature combustion, photochemical reactions or bacterial action, may react with other compounds in the air to form nitrate (NO_3^-) or nitric acid (HNO_3).

16.2 Effects

Nitrate and nitric acid are involved in corrosion of materials, visibility degradation and acidic precipitation. They may also have an adverse effect on human health.

16.3 Ontario Criteria

None

16.4 Sources

Nitrate is primarily a secondary pollutant. Anthropogenic sources of nitrogen oxides or nitrates include all high temperature combustion processes, transportation, and fertilizer production and usage. Natural sources include lightning, biological decomposiion and photochemical reactions.

16.5 Method of Monitoring

Nitrates collected on glass fibre filters by a High Volume Sampler are extracted by digestion in distilled water. This extract is reduced to nitrite followed by colourimetric analysis for determination of the mass concentration of atmospheric nitrate.

16.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Nitrate monitoring was carried out at 58 locations in 1989.

16.7 Monitoring Results

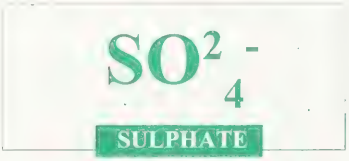
The distribution by percentile, the maximum, the arithmetic mean, and the geometric mean are given in the Appendix (Table A-36). Highlights of monitoring are summarized in Table 5.

The highest annual mean nitrate concentration (5.1 µg/m^3) occurred in Windsor (12008) and the highest concentration for a single day (28.0 µg/m^3) occurred in Toronto (31104).

16.8 Ten-Year Trend

The trend in mean annual NO^-_3 at locations which possess a ten-year record is shown in Table A-37 and is summarized for the province in Figure 6.

Since nitrate is primarily the result of medium and long range transport of air pollution, its variability is largely related to meteorological variability.



17.1 Characteristics

Sulphur dioxide is oxidized in the atmosphere to eventually form sulphate compounds. Intermediaries in the oxidation process such as H_2SO_3 and SO_3 rapidly combine with water vapour to form sulfuric acid aerosol. This type of process is dependent on atmospheric conditions.

17.2 Effects

Sulphate compounds have been linked to respiratory irritation and disease, corrosion of materials, reduction of visibility and the formation of acidic precipitation.

17.3 Ontario Criteria

None.

17.4 Sources

Sulphate is primarily a secondary pollutant. Anthropogenic sources of sulphur oxides include the burning of fuels containing sulphur (such as coal and oil), the smelting of sulphur-containing ores and the refining of petroleum. Natural sources include bacterial decomposition, volcanoes and forest fires.

17.5 Method of Monitoring

Sulphate collected on glass fibre filters by a High Volume Sampler is extracted by digestion in distilled water. This extract is analyzed colourimetrically and the mass concentration of sulphate is calculated. It has been found that artifact sulphates form on the glass fibre filters from ambient SO_2 and that reported sulphate concentrations are therefore artificially high. No attempt has been made to correct the data reported here.

17.6 Location and Frequency of Monitoring

The monitoring locations and the length of the sampling cycle (in days) for each location are indicated in the Appendix (Table A-3).

Sulphate monitoring was carried out at 58 locations in 1988.

17.7 Monitoring Results

The distribution by percentile, the maximum, the arithmetic mean, and the geometric mean are given in the Appendix (Table A-38). Highlights of monitoring are summarized in Table 5.

The highest annual mean sulphate concentration (12.1 µg/m^3) was measured at Hamilton (29102) and the highest concentration for a single day occurred at Sault Ste Marie (71042).

17.8 Ten-Year Trend

The variability of the annual means for sulphate (see Figure 6 and Table A-39) may be explained by meteorological variability as in the case of nitrate (Section 16.8).

TABLE 5 - HIGHLIGHTS OF THE PARTICULATE MONITORING NETWORK 1989

	TSP	Pb	Cr	Fe	Mn	Ni	NO^-_3	SO^{2-}_4
LOWEST GEOM MEAN LOCATION CONCENTRATION	DORSET (49010) 19 ug/m3	SEVERAL .01 ug/m3	KESWICK (48141) .003 ug/m3	SEVERAL 0.2 ug/m3	MOORETOWN (14031) .009 ug/m3	SEVERAL .005 ug/m³	SUDBURY (77016) 0.4 ug/m³	THUNDER BAY (63022) 4.2 ug/m³
HIGHEST GEOM MEAN LOCATION CONCENTRATION	HAMILTON (29011) 107 ug/m3	MISSISSAUGA (46041) 1.04 ug/m³	HAMILTON (29011) .025 ug/m³	S.S.MARIE (71042) 6.0 ug/m3	S.S. MARIE (71042) .392 ug/m³	COPPER CLIFF (77070) .328 ug/m³	WINDSOR (12008) 5.1 ug/m³	HAMILTON (29102) 12.1 ug/m³
PERCENTAGE OF SAMPLES ABOVE 24-HR AQC LOCATION VALUE	HAMILTON (29011) S.S.MARIE (71042) 42	MISSISSAUGA (46041) 7	 0	N/A	HAMILTON (29025) 2	COPPER CLIFF (77070) 8	N/A	N/A
NO. OF STATIONS EXCEEDING 24-HR AQC NUMBER	110	6	0	N/A	2	3	N/A	N/A
NO. OF STATIONS EXCEEDING 1-YR AQC NUMBER	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HIGHEST MEASURED VALUE - 24-HR LOCATION CONCENTRATION	TORONTO (31082) 870 ug/m³	MISSISSAUGA (46041) 21.99 ug/m³	TORONTO (31065) .290 ug/m³	S.S.MARIE (71042) 120 ug/m³	HAMILTON (29025) 3.950 ug/m³	COPPER CLIFF (77070) 4.360 ug/m³	TORONTO (31104) 28.0 ug/m³	S.S. MARIE (71042) 45.6 ug/m³
TOTAL NUMBER OF STATIONS NUMBER	152	84	53	62	54	57	58	58

Figure 5

10-Year Trend in Particulate Pollutants TSP,Pb and Fe

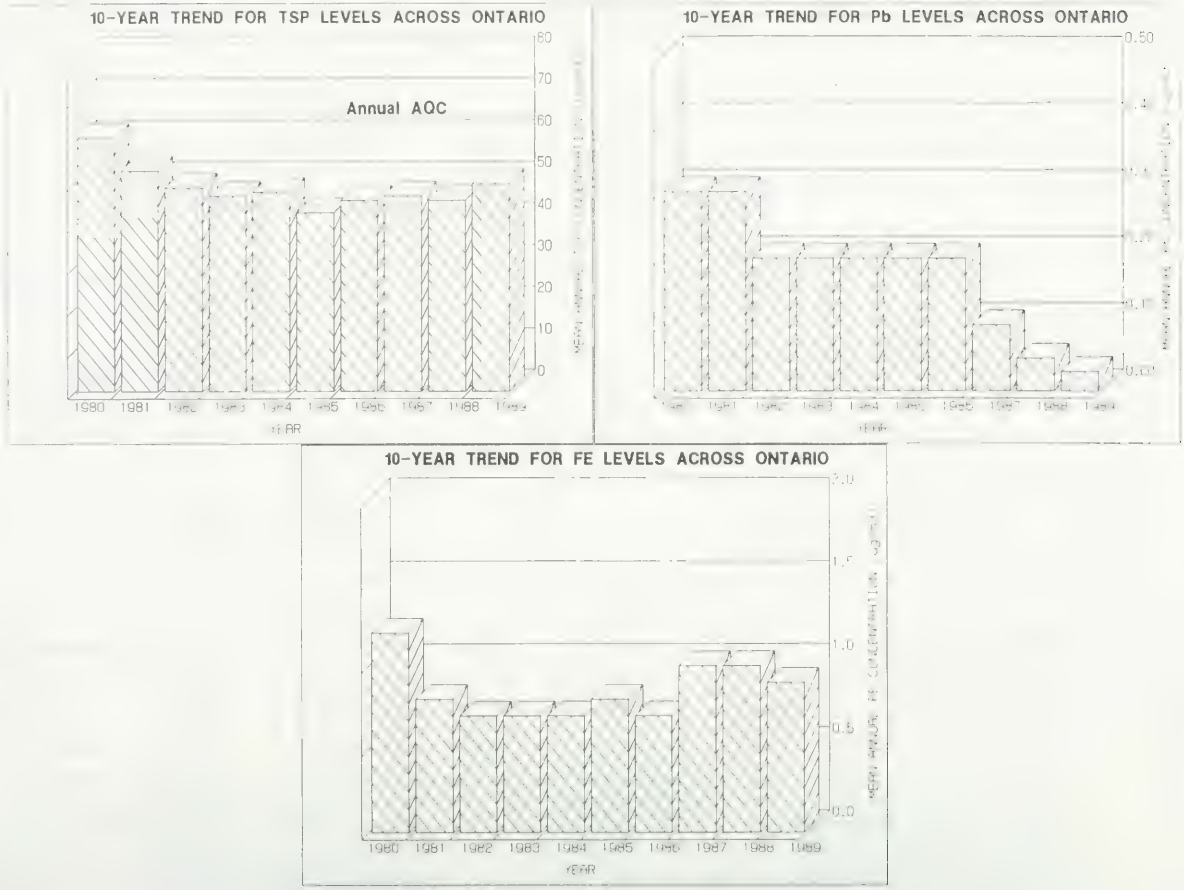
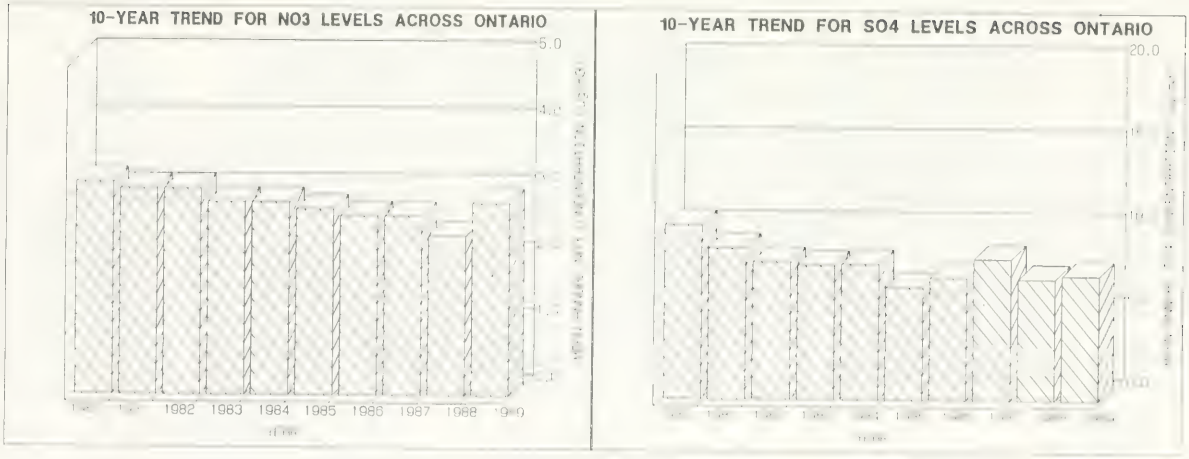


Figure 6

10-Year Trend in Particulate Pollutants NO_3 and SO_4



SECTION E METEOROLOGY AND AIR QUALITY

Weather conditions play a major role in the levels of air pollution. Weather factors which may affect air pollutant concentrations are:

- rainfall which may remove (washout) pollutants from the atmosphere;
- sunshine which causes photo chemical reactions of air pollutants which form smog;
- wind which transports and disperses pollutants emitted from sources;
- temperature which affects the amount of fuel used and the dispersion and chemical reactions of pollutants in the atmosphere.
- slow moving high pressure systems which allow pollutant concentrations to build up in the atmosphere.

18.0 Summary of Meteorological Conditions (1989)

For the third consecutive year, temperatures during the summer months were above normal, although the annual mean temperature in 1989 was below normal. The number of hours of bright sunshine was above normal for the winter, spring and fall seasons but was below normal during the summer months except during July when some locations in northern Ontario received up to 120% of normal values. Total precipitation for the year was slightly below normal but rainfall during the summer period was above normal.

Annual wind roses are presented in Figure 7 for selected meteorological sites across Ontario. The entire meteorological network is outlined in Table A-5 and Maps 6 and 7.

19.0 Discussion of Ozone and Suspended Particle Episodes

As mentioned in Section 9.0, ozone exceedances generally occur during the months May through September on hot sunny days with calm or light winds. In 1989, the number of hourly exceedances of ozone were well below the recorded totals during 1988; however, the 1989 annual average concentration was comparable to that of 1988 as shown in Figure 8. A comparison of the monthly averages revealed that the monthly average ozone levels during the summer of 1988 were higher than the summer of 1989. However, the monthly average ozone levels during the winter period of 1989 were higher than the corresponding winter months of 1988. The net result was a similar annual average ozone concentration in 1988 and 1989. No explanation is given at this time however, it is under investigation.

The highest ozone levels for 1989 were recorded during the episode of July 24 and 25. Temperatures across the province were in the low 30's, winds were light and the number of bright sunshine hours on both days were in excess of 12. Two days prior to the episode, back air trajectories showed that the air arriving in southern Ontario had originated from the mid-west United States and passed over the industrialized Ohio Valley area. At 0700 EDT on the 22nd, a high pressure system was centred over the southeastern U.S.A. By July 23rd, Ontario was experiencing a very light wind flow associated with this broad high pressure area. This air mass remained over Ontario until July 25th. During this time period, emissions from within Ontario were added to the ozone and its precursors which had previously been transported into the province, to produce the observed elevated ozone levels.

On July 26, a change in air mass occurred as rain associated with a low pressure system moved into the province and removed (through washout) the precursors conducive to ozone formation.

Elevated levels of suspended particles generally occur on days with light wind conditions when pollutants can be trapped close to the ground. As mentioned earlier, the number of cases when suspended particles exceeded the provincial criterion was second only to ozone during 1989.

The majority of SP exceedances were recorded during the period October 24 to 30, 1989. Monitoring sites in the Greater Metro Toronto areas were heavily impacted during this episode. The York site recorded moderate air quality for 67 hours and along with Etobicoke South it recorded the maximum one-hour AQI level of 73.

The October 24 to 30 period was characterized with very poor mixing resulting in pollutant buildup. The cause of this pollution buildup was a broad area of high pressure that stagnated over Ontario. On October 31, improved ventilation and dispersion conditions developed as the high pressure system was replaced by a cleaner air mass which moved into the province as a cold front swept eastward.

Figure 7 PERCENT FREQUENCY OF WINDS AT SELECTED SITES ACROSS ONTARIO

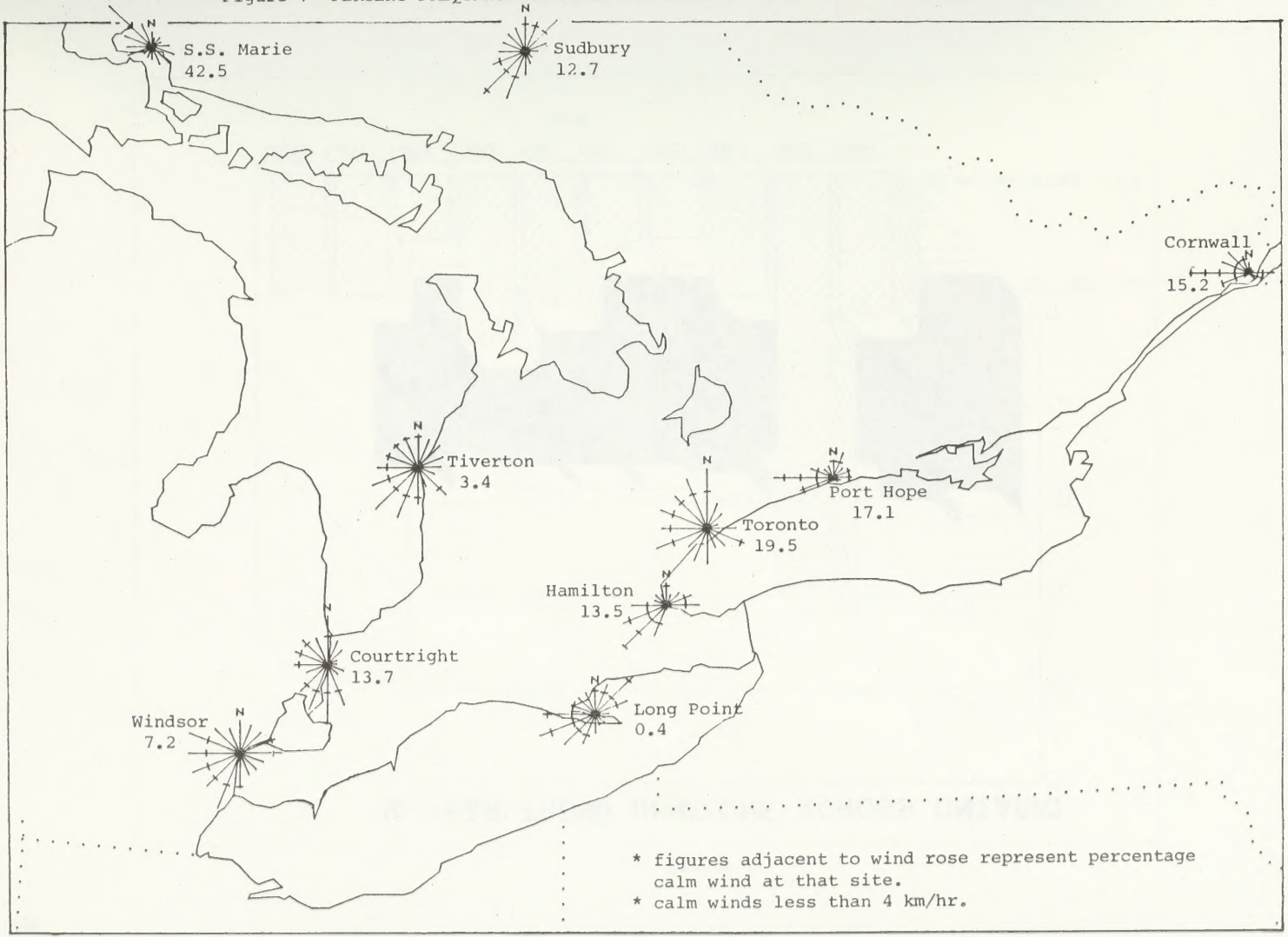
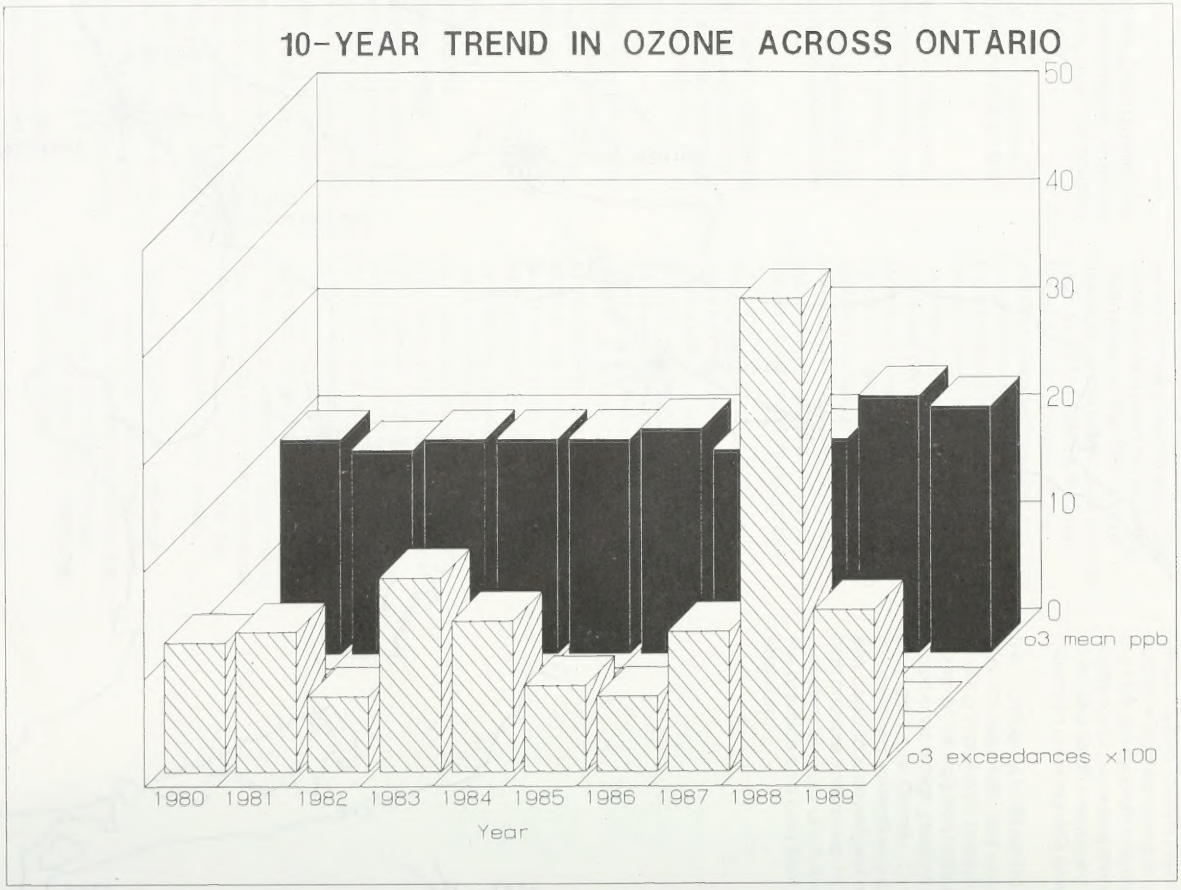


Figure 8


10-YEAR TREND IN OZONE ACROSS ONTARIO
50
40
30
20
10
0
o3 mean ppb
o3 exceedances x100
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
Year